

SOME PRELIMINARY OBSERVATIONS ON THE SUBMERGED AQUATIC *ZOSTERA CAPENSIS* SETCHELL

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ABSTRACT

The distribution of *Zostera capensis* along the South African coast and a morphological description of the plant is presented, together with some preliminary observations on laboratory germination and growth, and tolerance to changing environmental conditions.

These observations form the basis from which detailed research into vegetative and reproductive aspects of the growth cycle is being planned.

UITTREKSEL

VOORLOPIGE WAARNEMINGS VAN DIE ONDERWATERPLANT *ZOSTERA CAPENSIS* SETCHELL

Die verspreiding van *Zostera capensis* langs die Suid-Afrikaanse kus en die morfologie van die plant word behandel. Voorlopige waarnemings van ontkieming en groei in die laboratorium en verdraagsaamheid t.o.v. veranderende omgewingstoestande word bespreek.

Daar word beplan om toekomstige navorsing op die vegetatiewe en voortplantings siklus op die gegewens wat hier waargeneem is, te baseer.

INTRODUCTION

The submerged macrophyte *Zostera capensis* Setchell is the only known representative of the genus *Zostera* to occur in Southern Africa. Unlike its European and American counterparts, which appear as twelve distinct species, four of which are grouped in the subgenus *Zostera*, and eight in the subgenus *Zosterella* (Den Hartog), and which are now being subjected to intensive research, little is known about the life-cycle and phenology of *Zostera capensis*. Growing as it does in estuaries and intertidal mudflats, its importance lies not only in the shelter that it affords to a variety of organisms, but also in its availability as a nutrient source to the ecosystem, either as grazing or detritus. It has been accepted that seagrasses are highly productive, and it is probable that the primary productivity of *Zostera capensis* is comparable to the productivity of other seagrass ecosystems. *Zostera* is also thought to assist in the deposition of sediment carried under load, and acts as a sediment binding agent.

Like many seagrass localities of the world, our *Zostera* beds have been reduced by interference directly or indirectly attributable to man, and by deleterious environmental effects. Unfortunately, a fundamental lack of knowledge concerning the life-cycle of *Zostera capensis* has inhibited biological counter-measures being taken against this reduction, such as restocking programmes by

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transplantation and/or seed sowing. A continuation or increase in the imbalance which must already exist, will have a serious effect upon the many organisms so closely associated with *Zostera* and ultimately on the ecosystem as a whole.

The situation outlined above prompted investigations into the growth cycle and phenology of *Zostera capensis*, and this preliminary paper is an introduction to the plant, together with some phenological observations, both in the field and in the laboratory.

DISTRIBUTION

Zostera capensis is widely distributed along the east coast of Southern Africa, from Inhaca Island (Mozambique) in the north to the Southern Cape (R.S.A.). Its known distribution along the west coast is limited to two localities, the northern limit being Saldanha Bay (Fig. 1). The localities listed under Fig. 1 are those at which *Zostera* has been recorded, but it is possible that the distribution may be wider than indicated. This suggestion is based on two criteria. Firstly, there has not been a systematic search along all the South African estuaries, and secondly, the ease of incorrectly assuming the absence of *Zostera* because of an absence of aerial components when, in fact, the population is experiencing a seasonal "die-back" of aerial shoots after flowering, so that only rhizomes remain buried in the substrate.



FIG. 1
Recorded distribution of *Zostera capensis* Setchell, along the east and south-west coasts of South Africa.

DESCRIPTION

The morphology of *Zostera capensis* has been described in detail by Setchell (1933), Obermeyer (1966) and Den Hartog (1970).

The plant has two vegetative components, (namely) a creeping rhizome system, and erect turions or leaves (Fig. 2). The rhizomes are 1–4 mm in



FIG. 2

Zostera capensis Setchell, showing unbranched roots (R), rhizome (RH) and erect turions.

thickness with internodes 4–30 mm in length. Nodes have up to five unbranching roots, with lengths of up to 100 mm.

The erect turion consists of a leaf sheath, flattened with two membranous lobes, and a lamina of variable length, usually to a maximum length of 300 mm, although plants growing in deeper water have been found with laminae of 900 mm (Steinke, pers. comm.). Lamina width is 1–3 mm.

There are three nerves on either side of the midrib, which run parallel to each other, except for the distal end of the lamina, where they converge towards the apex. Cross-veins occur at intervals and are either at an angle to, or perpendicular to the midrib. The lamina apex is obtuse or emarginate, becoming cleft with age.

The reproductive or generative shoots are erect, 1–2 mm in width, and give rise to a variable number of peduncles, alternately arranged. Each peduncle is terminated by a spadix enclosed in a membranous overlapping spathe. The spathes are 10–20 mm in length and up to 3 mm in width. The spadices contain 3–16 male flowers and 3–6 female flowers, arranged in two parallel rows, in such a way that a female flower occurs between two male flowers (Fig. 3). The male flowers are sessile, unilocular anthers (Fig. 4), while the female flowers consist of unilocular ovaries each containing a solitary ovule (Fig. 5), a style and two



FIG. 3
Young inflorescence with immature male and female flowers.



FIG. 4
The male flower, a sessile, unilocular anther.



FIG. 5
The female flower consisting of two stigmatic arms, a style and a unilocular ovary.

stigmatic arms. The female flowers are protogynous. Pollen is filiform, and is produced in great quantities (Fig. 6).

Situated on the margins of the spadix at regular intervals are scale-like triangular structures, the retinacula (Fig. 7). The positions of these retinacula are such that each retinaculum subtends a group of flowers, composed of two male flowers and one female flower.

The seeds are ellipsoid, 2.6–3.0 mm in length, and have reddish-brown to black testas. The testas are characterised by longitudinal and fine transverse striations, and are resistant to pressure.

Plants having marked differences in leaf length have been found at a number of localities. It appears that plants growing in water shallow enough to allow regular exposure at low tides are generally short-leaved (maximum of 300 mm), while plants which are seldom, if ever exposed, have long leaves (maximum 900 mm). It is not known whether these morphological differences are due to genetic or environmental influences, and whether other phenotypic differences exist between the two forms.

GERMINATION AND SEEDLING DEVELOPMENT

Germination of seeds, as observed in the laboratory, under continuous regimes of temperature (18 °C) and salinity (20‰) and a photoperiod of 12 hours, begins with the longitudinal splitting of the testa and gradual protrusion of the embryo.

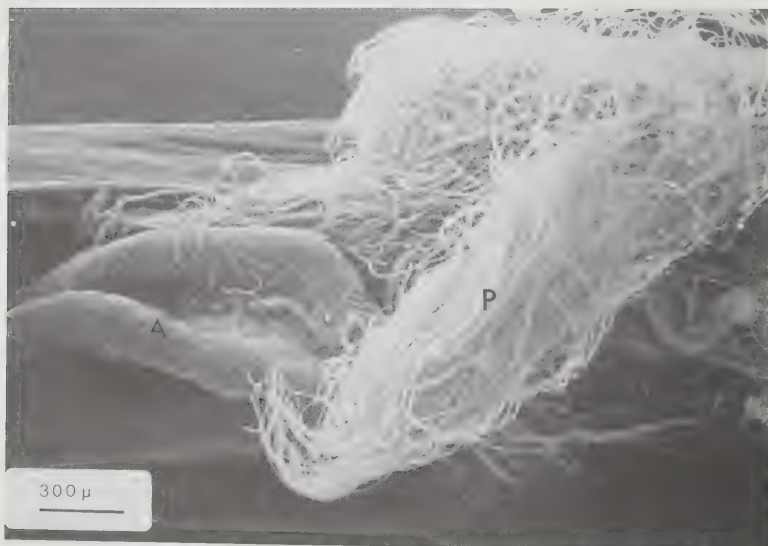


FIG. 6

A cloud of filiform pollen released from a dehiscing anther. P = pollen; A = anther.



FIG. 7

A retinaculum arising from the margin of the spadix.

The embryo is deeply grooved on one side, the groove corresponding to the longitudinal axis of the seed (Fig. 8). Terminating this scutellate embryo is a short hook-like structure, recurved towards the groove. Within the groove lies a cylindro-conic structure, which, as growth proceeds, increases in length, unfolds and protrudes from the embryo. It is suggested that the scutellate portion of the embryo is the cotyledon and the cylindro-conic structure the epicotyl. Concomitant with epicotyl development is the appearance of an outgrowth of tissue from a

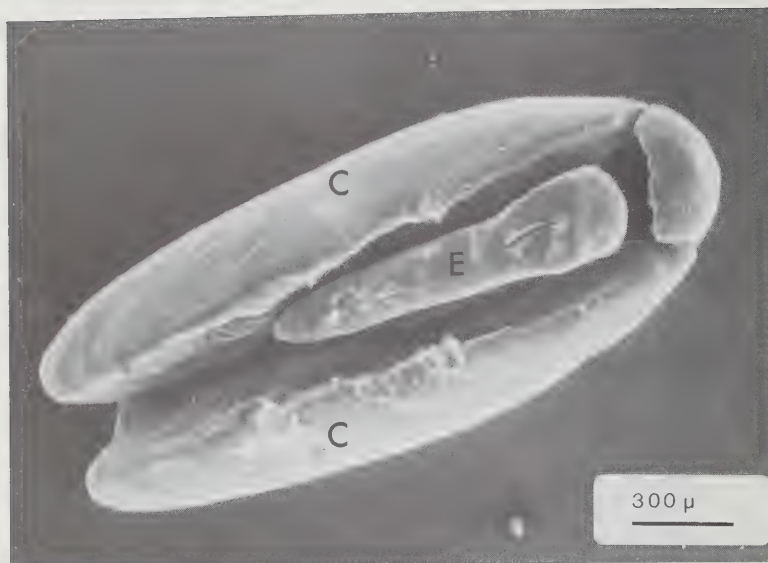


FIG. 8

Embryo composed of folded cotyledon (C) and trunk-like epicotyl (E).

point opposite the insertion of the epicotyl, and therefore opposite the cotyledonary groove. This outgrowth, described by Den Hartog (1970) as being a primary root common to subgenus *Zosterella*, is considered to be the radicle, by definition the rudimentary root of the embryo (Jackson, 1960). Its length increases to within a maximum of 20 mm (Fig. 9).

The epicotyl may vary in length, but is not usually longer than 20 mm. It is terminated by the first node, from which arise two or three lateral roots, and the plumule developing a fascicle of leaves, sheathed proximally by the coleoptile. By this stage of development the seedling is approximately three months old (Fig. 10).

Growth continues with increase in leaf-length and number and also in rhizome extension from the first node. Now leafy shoots arise from lateral and terminal buds, until after one year the plant consists of a branched rhizomatous system, with five to eight vegetative shoots and two or four reproductive shoots, which arise from terminal and lateral buds on the rhizome. The reproductive shoot can best be described as a rhipidium with two to five spathes (Den Hartog, 1970). The flowering period lasts about four months, and thereafter spathal decay and leaf senescence characterises a period in which growth is limited to the branching rhizome system.



FIG. 9

Emergent seedling with the epicotyl (E) arising from the cotyledonary groove, and developing radicle (R).

The plants on which these descriptions were based are still under observation at the present time.

LABORATORY CULTIVATION AND TOLERANCE TO SOME ENVIRONMENTAL CONDITIONS

Preliminary investigations into the response of *Zostera capensis* plants to controlled artificial conditions have indicated a tolerance to transplantation and



FIG. 10

A three month old seedling with well-developed fascicle of leaves and cotyledon still attached to the epicotyl.

environmental change, with the advantage that phenological investigations can be made in the laboratory, as a parallel to those made in the field. This tolerance to changing conditions is manifested not only in vegetative growth alone, but also to a certain extent in reproductive growth.

It is difficult in a preliminary investigation to ascribe specific growth responses and therefore tolerance levels to any particular environmental influence, since

Photoperiod and light intensity

Plants subjected to photoperiods of 12–15 h grew well and flowered, as was expected since these periods correspond to field conditions when flowering has been observed. However, plants grown in a photoperiod of 6 h flowered as profusely as those in 12–15 h light regimes. It would appear that short photoperiods are not a limiting factor to vegetative or reproductive growth, provided light intensity remains above a certain level. Field intensity measurements and further investigations in the laboratory have yet to be done, but it is likely that low light intensity levels (eg. tidal action, turbidity, epiphytic shielding effects) result in very short-leaved forms with restricted reproductive growth. These observations are comparable to light intensity effects reported for eelgrass by Backman & Barilotti (1976), and reviewed by Boone & Hoeppel (1976).

Germination

Phillips (1976) reported field observations which indicate low germination rates of seagrass seed, and low success rates in the establishment of germinated seedlings. A low germination rate of *Z. capensis* seed has been obtained in this laboratory, with 4% of seed stored under ambient conditions (18 °C water temperature and 20‰ salinity) germinating after five months. Further germination occurred irregularly to give 15% germination after one year storage. Preliminary investigations involving differential treatments of salinity, temperature and light intensity have failed as yet to increase percentage germination. Testa removal resulted in limited epicotyl extension in some embryos, but these died after five weeks. It is not yet certain whether the low germination rate is due to low viability, quiescence imposed by adverse conditions, or some form of dormancy. Seeds have not been collected in sufficient numbers to enable viability and other relevant tests to be performed.

The transplantation of four-month old seedlings into aquaria where conditions were maintained as close as possible to those experienced in the field, viz. salinity 25‰, temperature 20 °C, substrate of fine mud, resulted in a 50% survival rate. The survivors grew vigorously and flowered 10 months after transplantation. There is no doubt that *Z. capensis* is amenable to transplantation into the laboratory, and whilst seedling mortality has been high so far, the establishment of older plants has been completely successful.

BIOMASS DETERMINATIONS

Biomass determinations (standing stock in g/m²) were initiated on a reduced, short-leaved population of *Z. capensis* in the Mlalazi Estuary, Zululand, with the average standing stock for a five month period being 60,26 g/m². This is low when compared with average seasonal maximum biomass ranges of eelgrass (*Z. marina*) of 97,55 g/m² to 1 463,24 g/m², and the average standing stock of eelgrass in the Izembek lagoon, Alaska of 243,88 g/m² (Boone & Hoeppel, 1976). Although

these plants are of a short-leaved type, it is probable that the low average standing stock is due in part to flooding of the Mlalazi River, which occurred during the sampling period. This work is being continued, together with biomass determinations at other localities.

DISCUSSION

The preliminary phenological observations described above have been useful in establishing direction for detailed investigations into vegetative and reproductive aspects of the growth cycle. Germination of seeds in the laboratory enabled observations to be made on seedling growth and development, through the first flowering stage until spathal decay. Preliminary observations on responses to varying environmental conditions indicate that these plants are able to tolerate changes of salinity, temperature, photoperiod and light intensity. At this stage emphasis is being placed on gaining a greater understanding of flowering and germination stimuli, to enable plants to be cultivated in the laboratory over a number of generations.

The characteristic senescence of erect components of *Zostera* after flowering and seed development has been briefly mentioned (see DISTRIBUTION). The frequency of growth, flowering and decay after seeding is in question, although some field observations indicate that profuse flowering as exhibited by a whole population at a given locality is a two year event. To what extent rhizome decay follows vegetative and reproductive decay is not known. It is hoped that careful monitoring of large field populations will clarify the situation.

Of particular interest is the elucidation of the state of the seed prior to germination. The terms quiescence and dormancy as previously used, need to be defined here, to ensure clarity of meaning. Quiescence is a state of arrested development maintained solely by unfavourable conditions, while dormancy is a state of arrested development imposed by the organism itself. The germination rate of 15% for seeds stored at a temperature of 18 °C, and a salinity of 20‰ for one year suggests the possibility of dormancy rather than quiescence where one would expect an all or none process, that is, no germination or a high rate of germination. It may be that these seeds have slow and differential rates of embryo maturation, coupled with a low viability. Extensive tests have been planned to investigate this phenomenon.

It has been suggested by Phillips (1976) that seagrasses may develop physiological races due to local climatic conditions and that transplantation into new geographic localities may require a period of acclimation. As far as *Z. capensis* is concerned, material for laboratory cultivation has been collected from Zululand and the Eastern Cape, and growth responses have indicated an ability to adapt to certain environmental changes without the need for acclimation. This suggests that the climatic differences experienced by the plants are within a tolerance range where growth is not noticeably affected after transplantation.

Acclimation may be necessary for plants collected from and transplanted into more diverse environments, but to what extent this would be successful is not known.

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